CSE 331

Cloning objects

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based on materials by M. Ernst, S. Reges, D. Notkin, R. Mercer, Wikipedia
http://www.cs.washington.edu/331/

Copying objects

- In other languages (common in C++), to enable clients to easily make copies of an object, you can supply a *copy constructor* :

```
// in client code
Point p1 = new Point(-3, 5);
Point p2 = new Point(p1);      // make p2 a copy of p1


// in Point.java
public Point(Point blueprint) {   // copy constructor
    this.x = blueprint.x;
    this.y = blueprint.y;
}
```

  - Java has some copy constructors but also has a different way...

Object clone method

```
protected Object clone()
        throws CloneNotSupportedException
```

- Creates and returns a copy of this object. General intent:
  - `x.clone() != x`
  - `x.clone().equals(x)`
  - `x.clone().getClass() == x.getClass()`
    - (though none of the above are absolute requirements)

- The `Object` class's `clone` method makes a "shallow copy" of the object, but by convention, the object returned by this method should be **independent** of this object (which is being cloned).

Protected access

```
protected Object clone()
        throws CloneNotSupportedException
```

- **protected**: Visible only to the class itself, its subclasses, and any other classes in the same package.
  - In other words, for most classes you are not allowed to call `clone`.
  - If you want to enable cloning, you must override `clone`.
    - You should make it `public` so clients can call it.
    - You can also change the return type to your class's type. (good)
    - You can also not throw the exception. (good)
  - You must also make your class implement the `Cloneable` interface to signify that it is allowed to be cloned.

The Cloneable interface

```
public interface Cloneable {}
```

- Why would there ever be an interface with no methods?
  - Another example: `Set` interface, a sub-interface of `Collection`

- **tagging interface**: One that does not contain/add any methods, but is meant to mark a class as having a certain quality or ability.
  - Generally a wart in the Java language; a misuse of interfaces.
  - Now largely unnecessary thanks to *annotations* (seen later).
  - But we still must interact with a few tagging interfaces, like this one.

- Let's implement clone for a `Point` class...

Flawed clone method 1

```
public class Point implements Cloneable {
    private int x, y;
    ...
    public Point clone() {
        Point copy = new Point(this.x, this.y);
        return copy;
    }
}
```

- What's wrong with the above method?

The flaw

```
// also implements Cloneable and inherits clone()
public class Point3D extends Point {
    private int z;
    ...
}
```

- The above `Point3D` class's `clone` method produces a `Point`!
  - This is undesirable and unexpected behavior.
  - The only way to ensure that the clone will have exactly the same type as the original object (even in the presence of inheritance) is to call the `clone` method from class `Object` with `super.clone()`.

Proper clone method

```
public class Point implements Cloneable {
    private int x, y;
    ...
    public Point clone() {
        try {
            Point copy = (Point) super.clone();
            return copy;
        } catch (CloneNotSupportedException e) {
            // this will never happen
            return null;
        }
    }
}
```

- To call `Object`'s `clone` method, you must use `try/catch`.
  - But if you implement `Cloneable`, the exception will not be thrown.

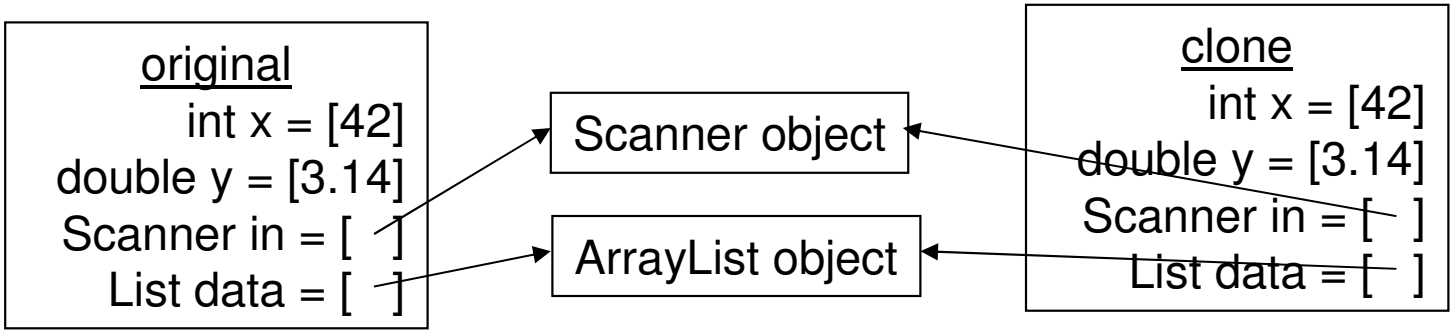
Flawed clone method 2

```
public class BankAccount implements Cloneable {
    private String name;
    private List<String> transactions;
    ...
    public BankAccount clone() {
        try {
            BankAccount copy = (BankAccount) super.clone();
            return copy;
        } catch (CloneNotSupportedException e) {
            return null;   // won't ever happen
        }
    }
}
```

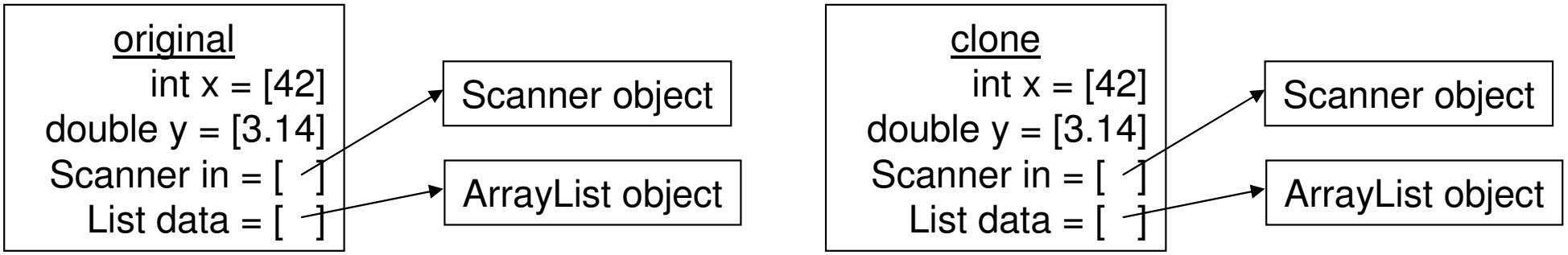
- What's wrong with the above method?

Shallow vs. deep copy

- **shallow copy**: Duplicates an object without duplicating any other objects to which it refers.



- **deep copy**: Duplicates an object's entire *reference graph*: copies itself and deep copies any other objects to which it refers.



  - `Object`'s `clone` method makes a shallow copy by default. (Why?)

Proper clone method 2

```
public class BankAccount implements Cloneable {
   private String name;
   private List<String> transactions;
   ...
   public BankAccount clone() {
      try {                  // deep copy
         BankAccount copy = (BankAccount) super.clone();
         copy.transactions = new ArrayList<String>(transactions);
         return copy;
      } catch (CloneNotSupportedException e) {
         return null;   // won't ever happen
      }
   }
}
```

- Copying the list of transactions (and any other modifiable reference fields) produces a deep copy that is independent of the original.

Effective Java Tip #11

- **Tip #11**: Override `clone` judiciously.

- Cloning has many gotchas and warts:
  - protected vs. public
  - flaws in the presence of inheritance
  - requires the use of an ugly tagging interface
  - throws an ugly checked exception
  - easy to get wrong by making a shallow copy instead of a deep copy